LOW NOx CONTINUOUS EMISSIONS MEASUREMENTS FROM GAS TURBINES

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Background

- CARB Low NOx Committee
- UC Riverside CE-CERT Low NOx Study
- Dow Chemical Project (Gluck et. al.)
- GE N0x Analyzer Study
- Horiba Low NOx study (Downey et. al.)
- Baldwin Low NOx projects (Budd/Baldwin)
- USEPA method update (Harrison et. al.)

Issues

- Can a CEMS measure NOx at 1–10 ppmv in the real world?
- Can a CEMS measure NH_3 with sufficient accuracy for compliance or control?
- What must change in system design?
- What must change in O & M to make the accuracy sustainable?
- What must change in Reference Methods and stack testing procedures to support low NOx?
- What must change in monitoring equipment to enable low NOx (and $NH_{3)}$ measurement?

Systems Approaches

- **Dilution -**
  - Concentrations too low for practical accurate measurements
  - Systems cost
  - Doesn't eliminate NH_3 contamination
  - Wet basis, requires water measurement (system bias)

- **Hot/Wet**
  - Doesn't eliminate NH_3 contamination
  - Heated analyzers - cost
  - Wet basis, requires water measurement (system bias)

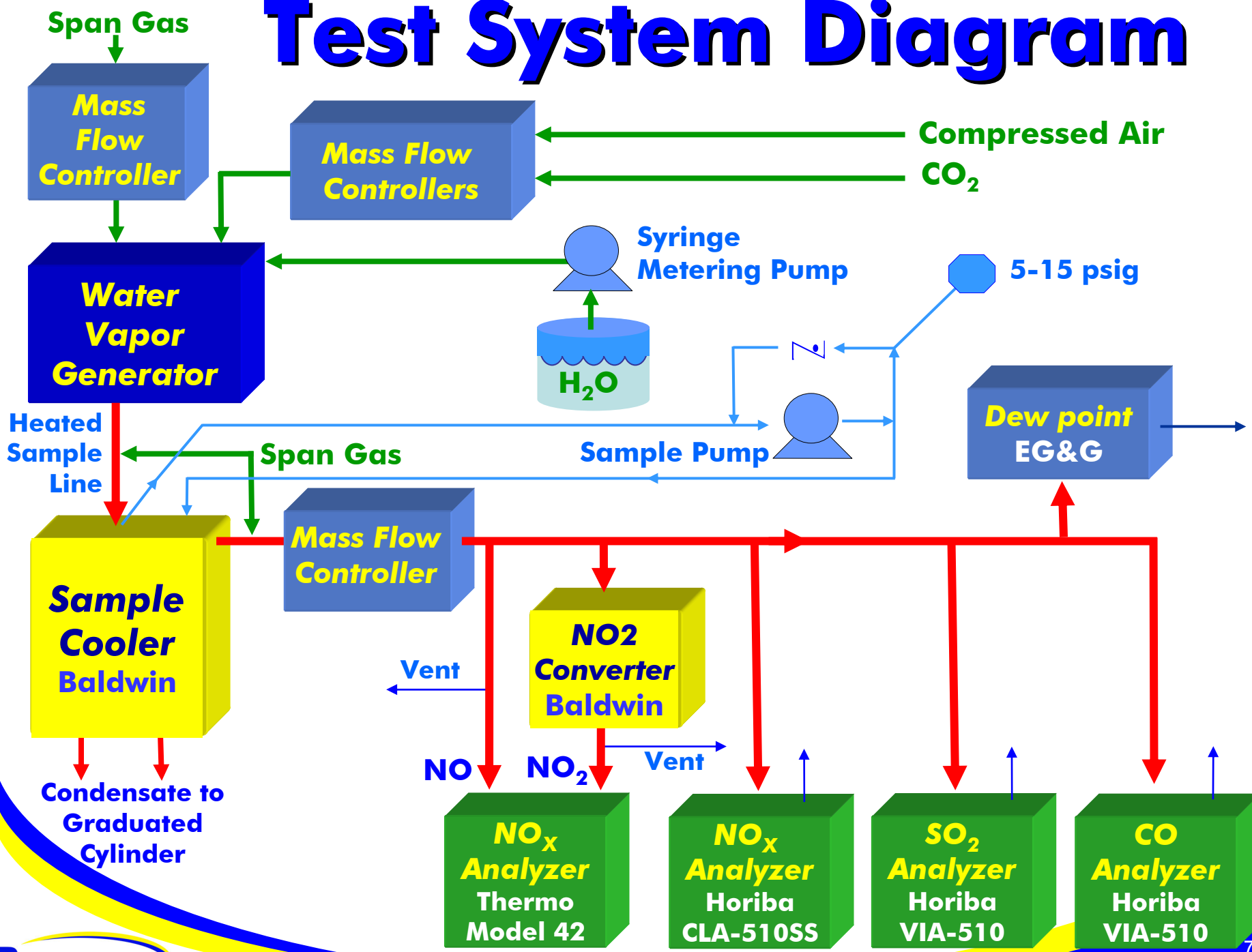
Conventional Extractive

- ***Results show excellent accuracy***
- ***Dry basis***
  - Same as reference method
    - Ease of certification
    - Direct reporting
  - No water measurement biases
- ***Simpler system design***
- ***Lower N0x bias further by moving NOx Converter to sample point***
  - Reduces bias from NO_2 loss
  - Makes system maintenance less critical

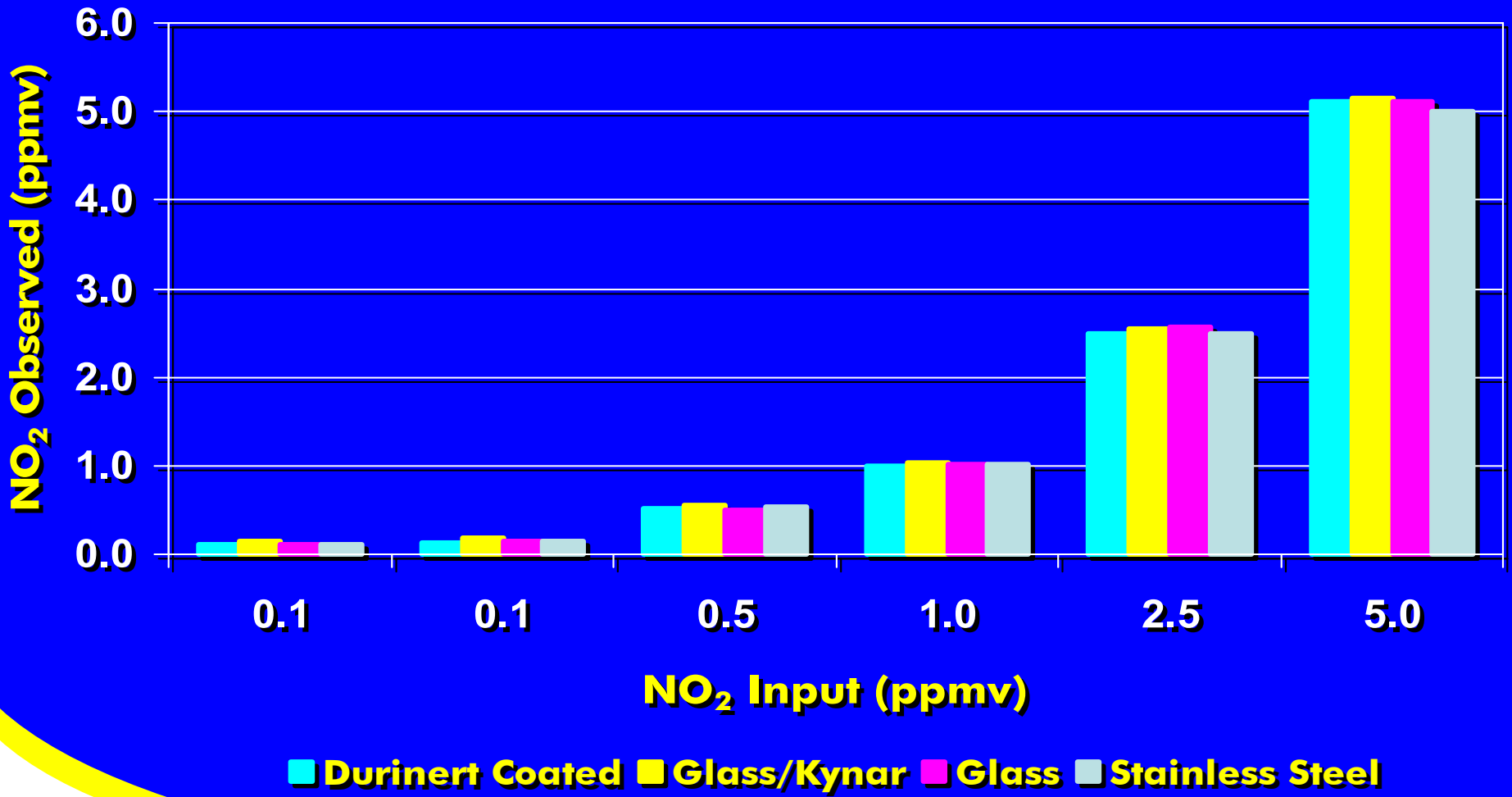
Standard Test Conditions

- NO/NO_2 : variable 1-15 ppm
- Ammonia : 0–15 ppm
- CO_2 : 0-5% vol
- Water : 10% vol

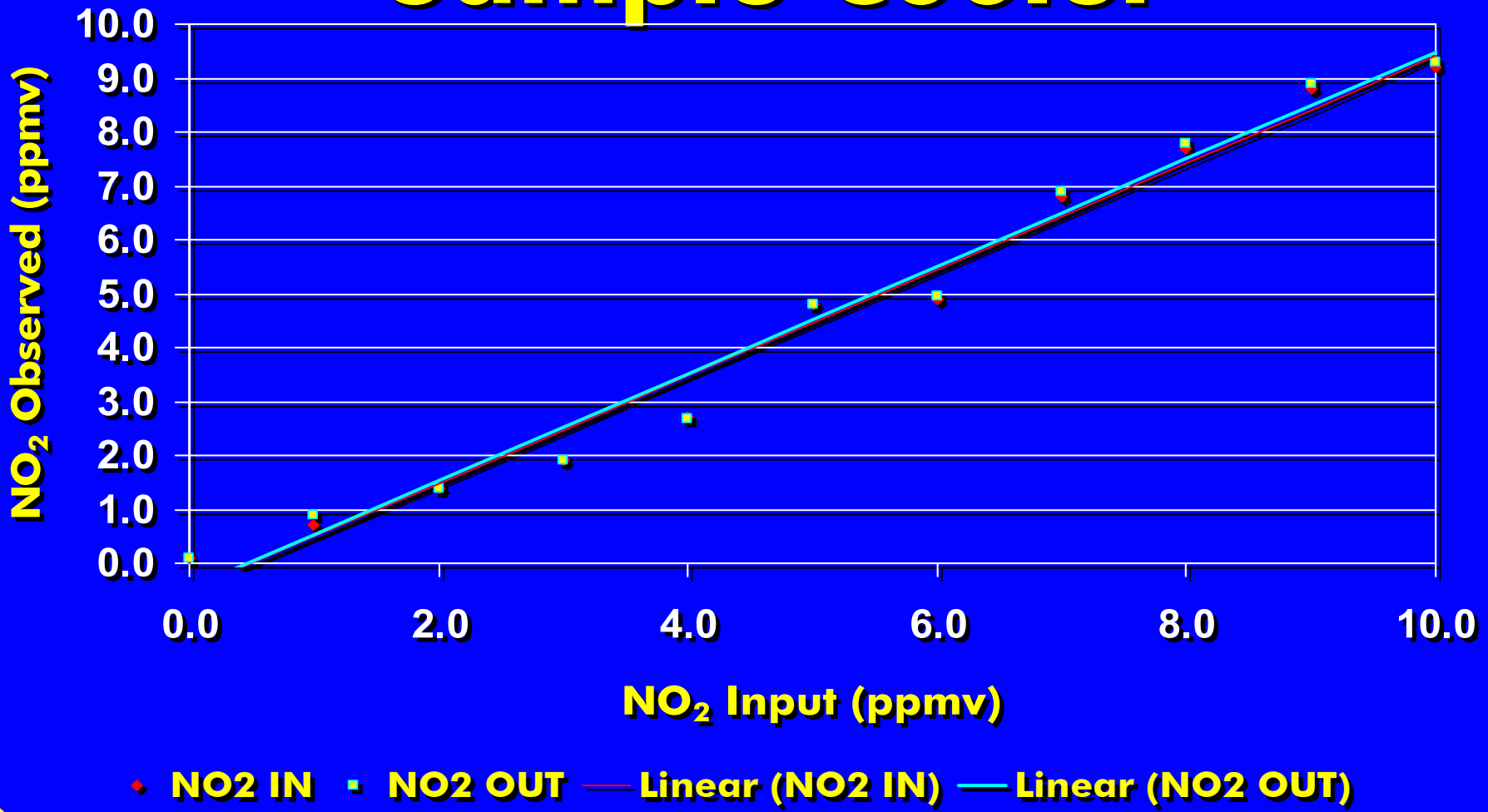
Test System Diagram



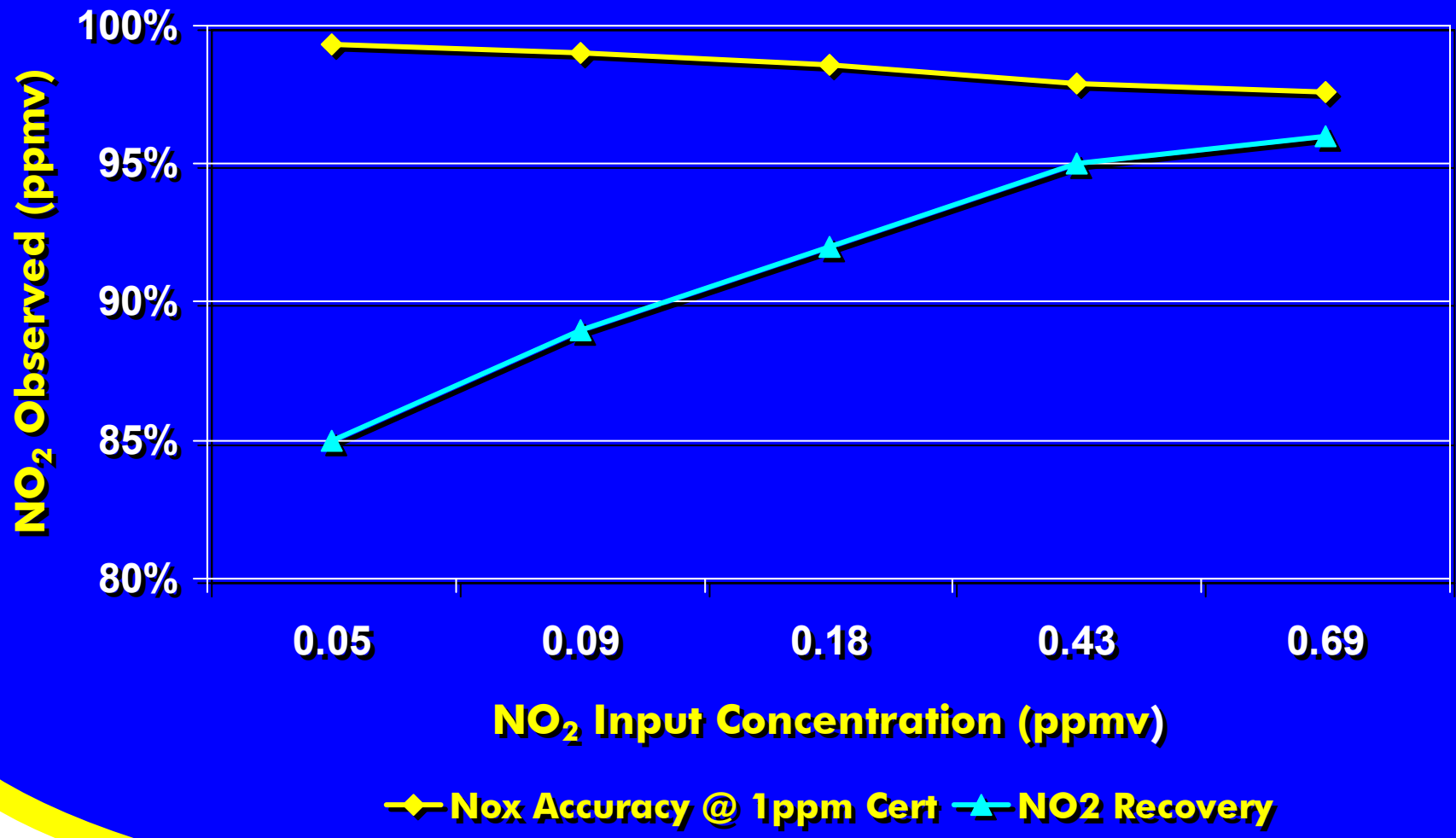
Impinger Material Effects On NO_2 Absorption



NO_2 Transport Through Sample Cooler



NO_2 Loss: Impact on Certification Accuracy



Conclusions: NOx Only

- ***Down to 1ppm with up to 70% NO_2 is measurable to better than ±5%***
  - Must use Low NOx components in system
  - System must be kept "Low NOx" clean
  - Chemi Analyzer must not have CO_2 error
  - High NOx exposure will bias results in a conventional system design

- ***Stack tester***
  - Low NOx Reference System
  - Low NOx measurement familiarity

Reduce "Sensitivities"

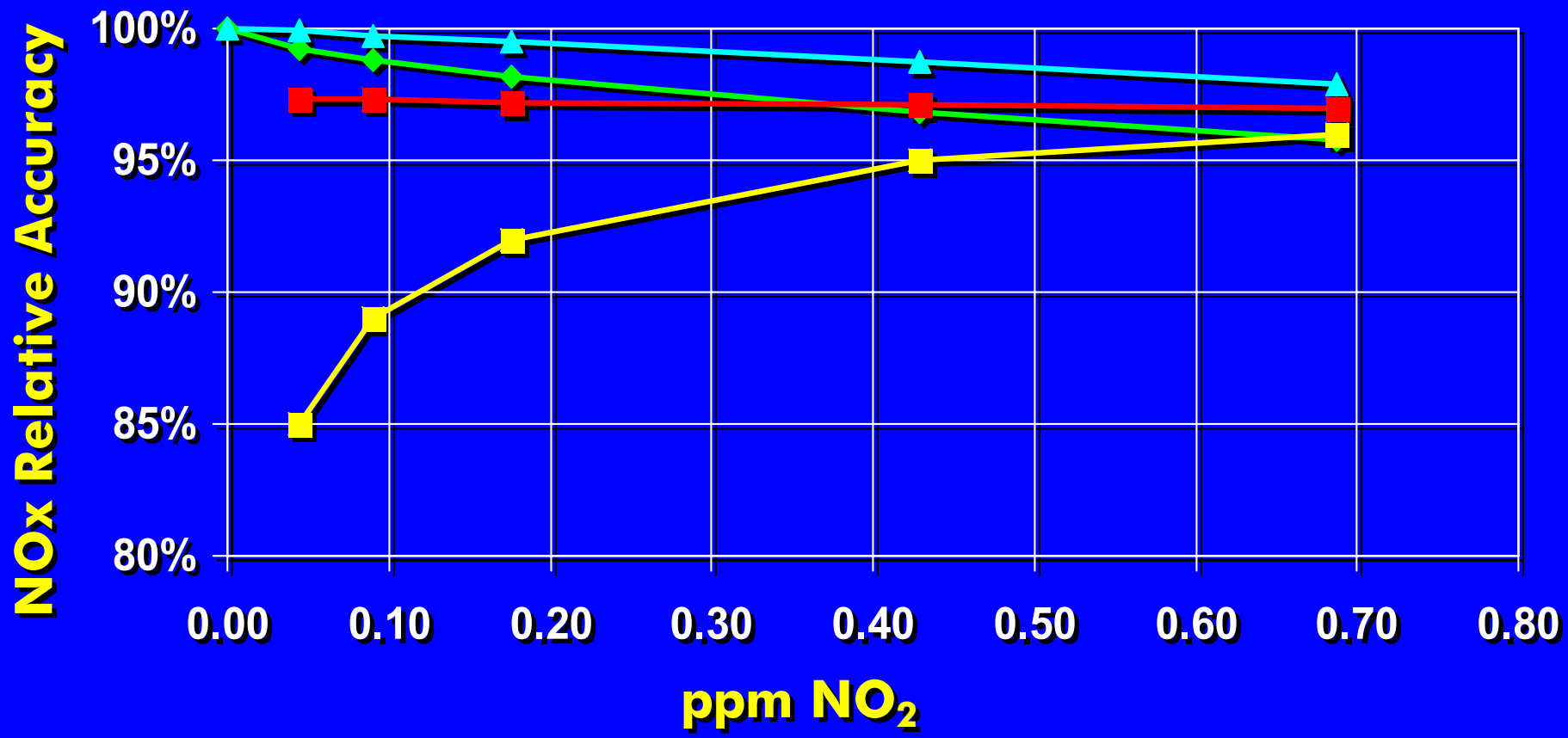
- NO_2 is the sensitive point
  - Permeates Sample line
  - Soluble in water (accounts for cooler loss)
  - Chemically reactive

- System components
  - Clean sample line
  - Treated sampling system components (Durinert)

Eliminate NO_2 Biases: Do Conversion at the Sampling Point

- ***Eliminates NO_2 bias***
  - High levels of NO_2 @ startup/shutdown
  - Loss in sample line
  - Loss in water removal system
- ***Converter issues***
  - >95% conversion efficiency @ 2 l/min
  - Reliable – less maintenance than sample filter
- ***Can be adapted to NH_3 measurement***

On Stack NO_2 Conversion: Improvement in Relative Accuracy



Add an SCR (NH_3)

- ***NOx Biases***
  - Variable NO_2 Losses - NH_3 + NO_2
  - Analyzer sample cell contamination
  - Sample line contamination

- ***Variable NH_3 Losses – up to 100%***
  - Presence of acidic gases (CO_2, SO_2, NO_2…)
  - Sample line

NOx Measurement with SCR

- ***Remove NH_3 at sample point for NOx only***
  - **Minimizes system contamination**
  - **Eliminates NH_3 interference**
    - **$NH_3 + 0_2 = NO$ in typical NOx converter**
    - **Even with carbon converter, NH_3 contamination is an issue**
- ***Must deal with NH_3 Scrubber issues***
  - **H_3PO_4 is most reliable system**
  - **NO_2 Loss**

Ammonia Scrubber

- ***Eliminates usual NH_3 Scrubber problems***
  - **90°C operation eliminates condensate issue**
- ***Does remove 12% of NO_2***
  - **Our data shows this is repeatable from 0.5–15 ppm NO_2**
  - **Not an issue in normal turbine operation where NO_2 is only 5-20% of NOx (@10% NO_2, 12% loss is only a 1.2% bias in the NOx value)**
  - **If 12% NO_2 loss is an issue, NO_2 Selective Converter in front of scrubber eliminates problem**

On Stack Converter Performance

- ***Inconel/stainless converter***
  - NO_2 : 97.3% @ 2 l/min
  - NH_3 : >90% @ 2 l/min
  - Synergistic NOx/NH_3 effect

- ***Low temperature carbon converter***
  - NO_2 : 98% @ 2 l/min
  - NH_3 : <1% @ 2 l/min

NOx Measurement Conclusion

- Certifiable NOx measurements are possible with conventional extractive systems down to 1ppm NOx even with high NO_2 present and in the presence of low ppm NH_3
- Errors/Biases can be reduced by conversion of NO_2 to NO at the sampling point
- Ammonia can be reliably removed as an interferent when SCR's are in use